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Z-RAM and the Cinderella Effect

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Fall Processor Forum
2005

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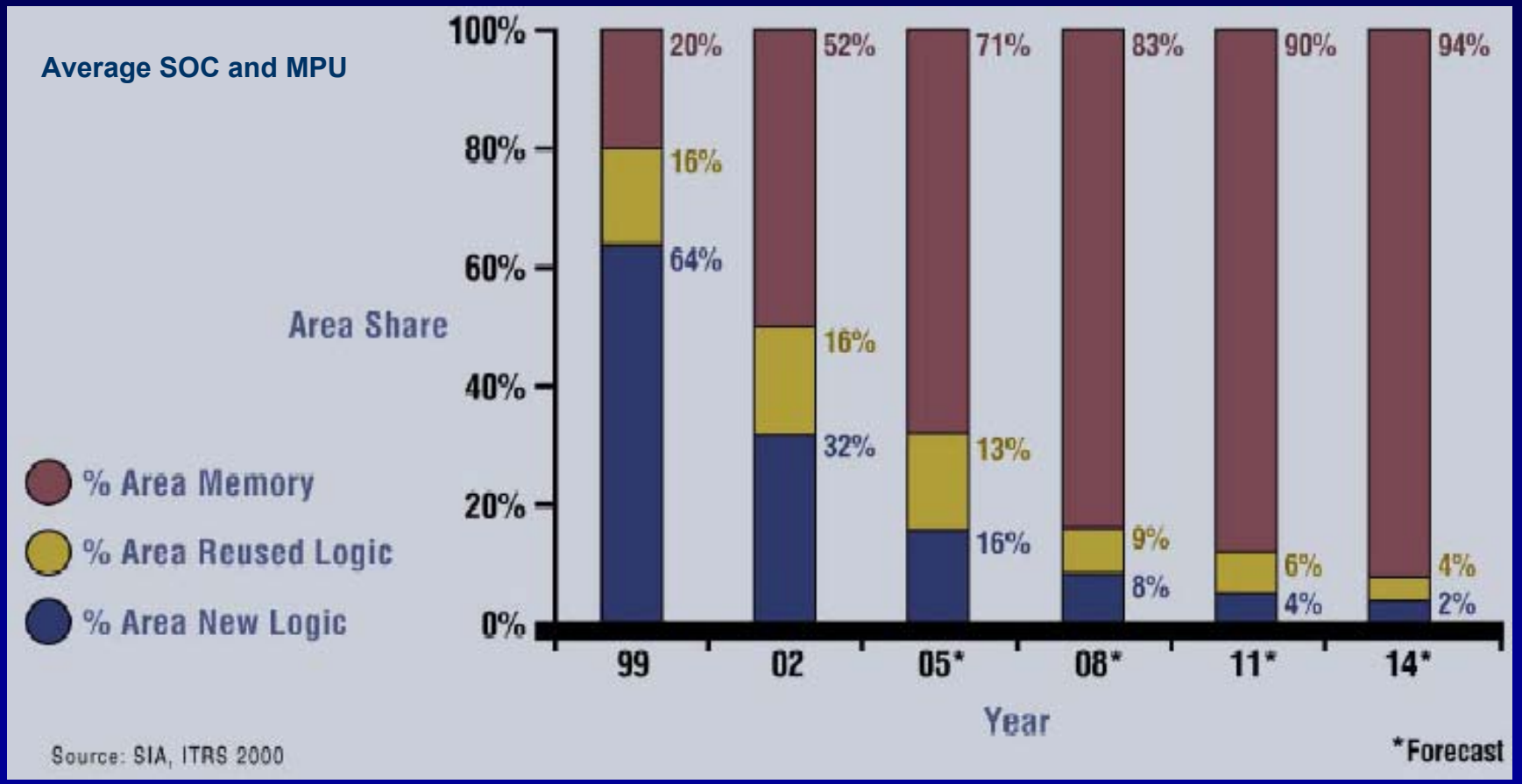
Embedded memory's changing role



- Embedded memory now dominates die area/cost

Existing on-chip memory technologies are reaching the limits of scaling

SRAM scaling problems

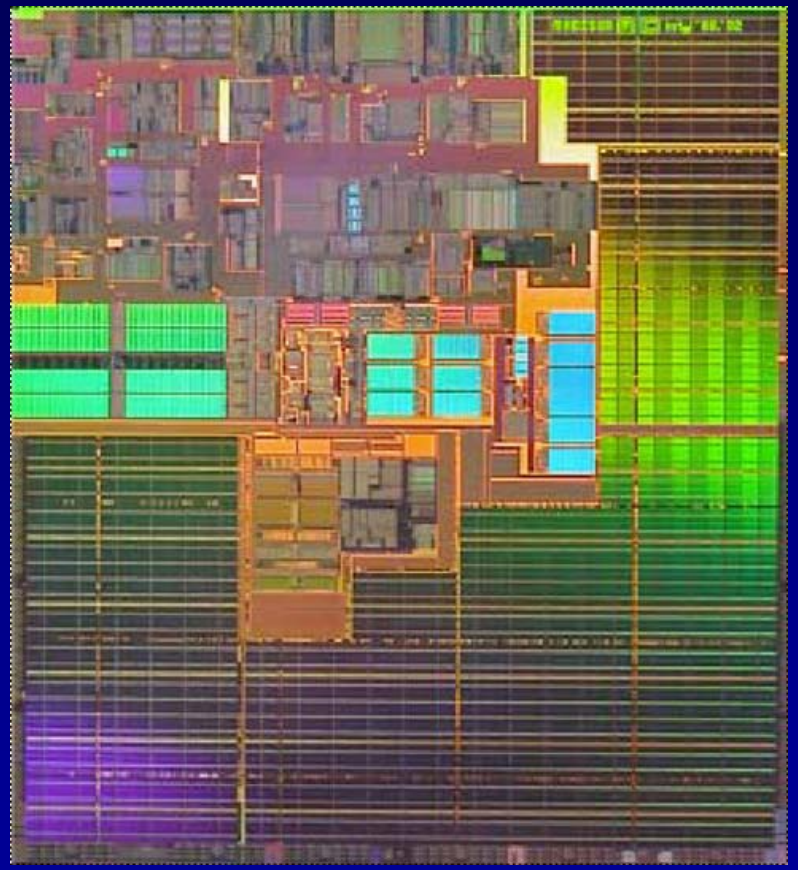
- Low density: occupies too much die area
- Soft-error rate increasing with process scaling
- Leakage increasing with process scaling

Microprocessor evolution

8080
~25mm²
(6µ process)

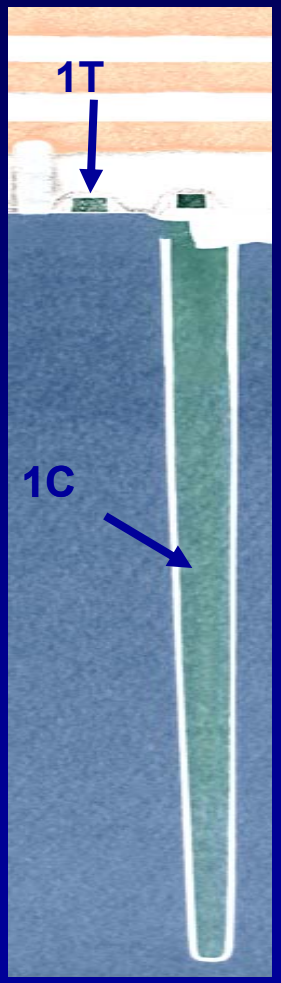
8080: no caches

Itanium: caches occupy 68% of die, or ~11x total 8080 die area



Itanium
~400mm²
(90nm process)

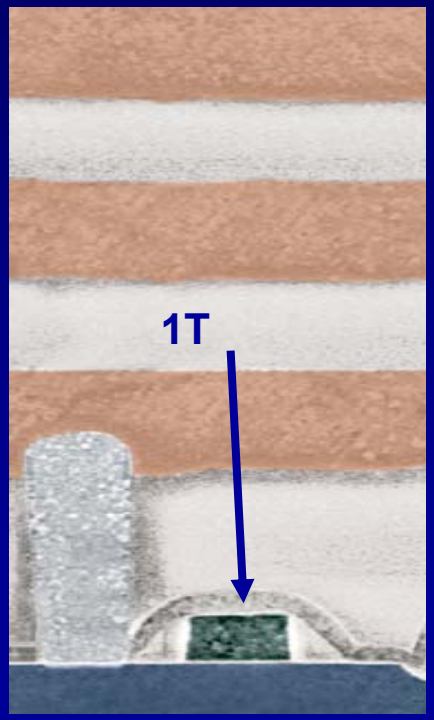
Scalability challenge for eDRAM



eDRAM

- DRAM trench/stack aspect ratio
  - Huge manufacturing challenge
  - Barrier to scaling beyond 90nm
- Deep trench incompatible with SOI
  - Limits availability on future processes
- High capacitance bit cell
  - Active power penalty

Z-RAM



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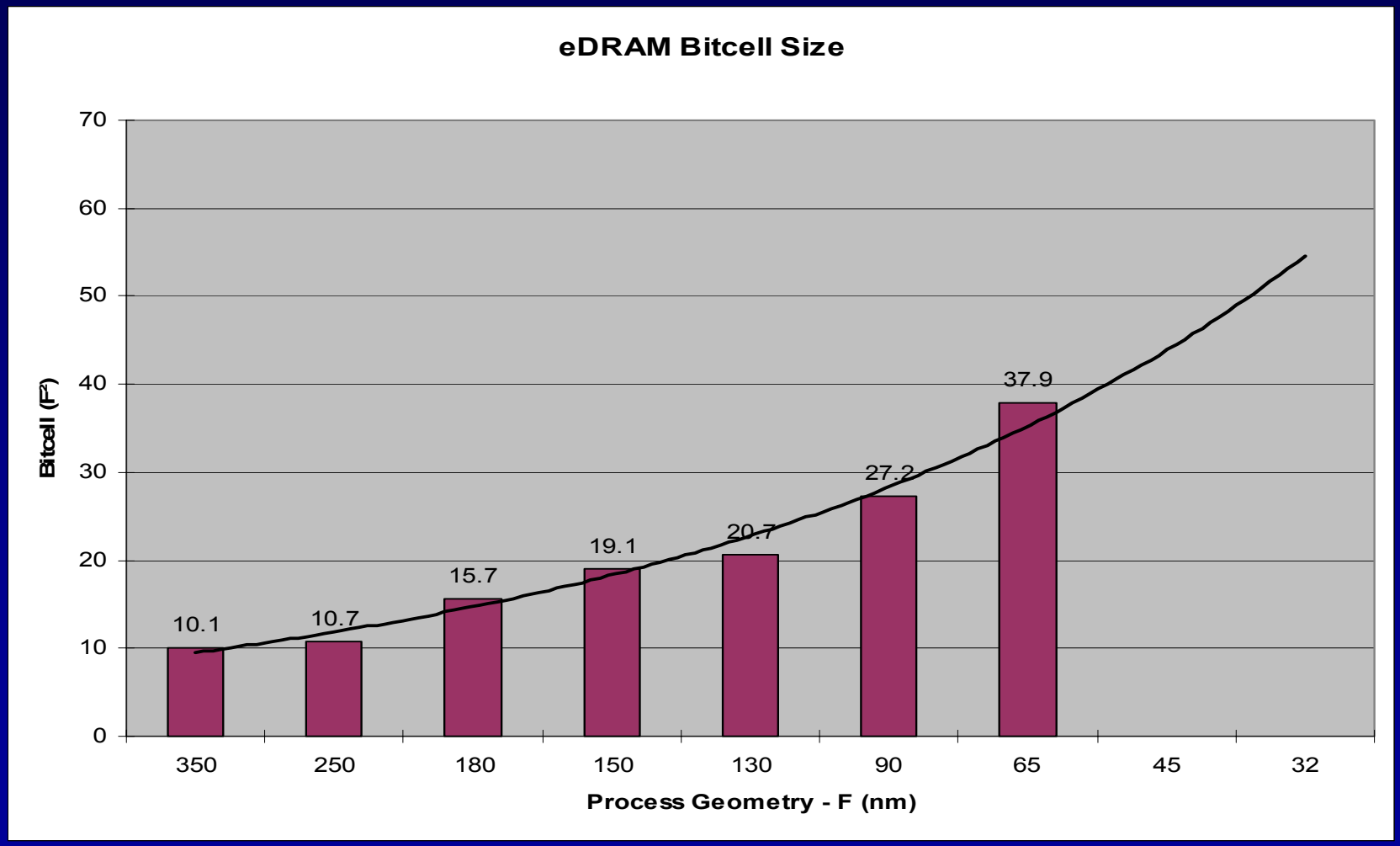
eDRAM reaching the scaling limit



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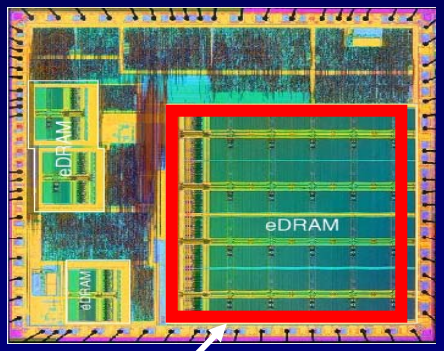
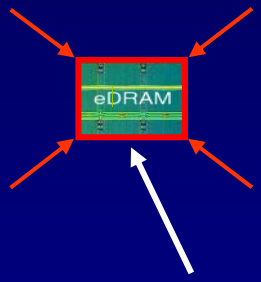
Introducing Z-RAM

ISi's patented memory technology



Traditional embedded memory

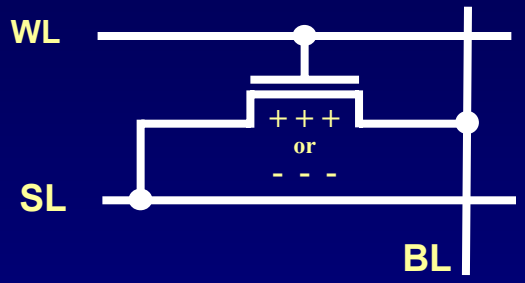


Innovative Silicon's Z-RAM embedded memory technology

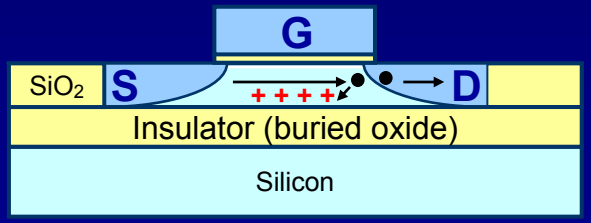
- ISi leverages silicon-on-insulator (SOI) technology to **reduce the die area** (& hence cost) of memory by **2x** (vs. eDRAM) or **5x** (vs. SRAM) at the same process geometry
- This makes Z-RAM the **lowest cost** of all semiconductor (R/W) memory technologies
- **Reverses economics**; for most chips this makes SOI **lower cost** than bulk CMOS
- Z-RAM requires **no extra steps or masks** on standard SOI logic process

Z-RAM bit cell: One transistor, Zero capacitors

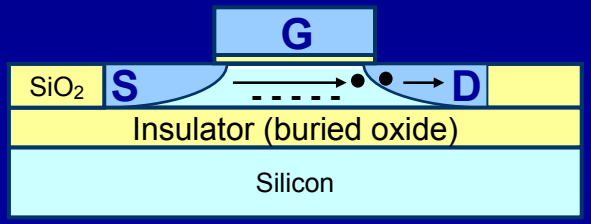
- Exploiting the floating body and gain effects of SOI devices

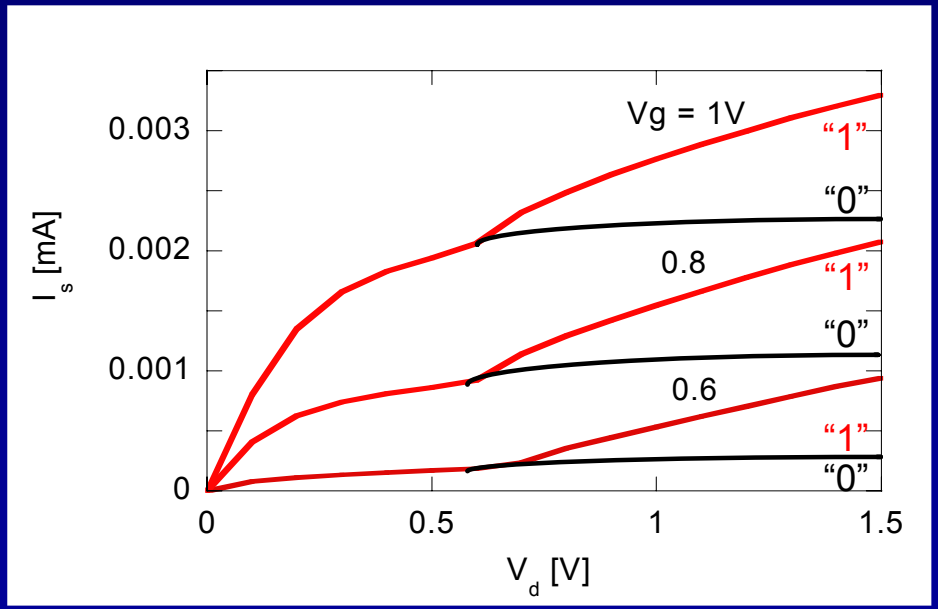


Logic "1"

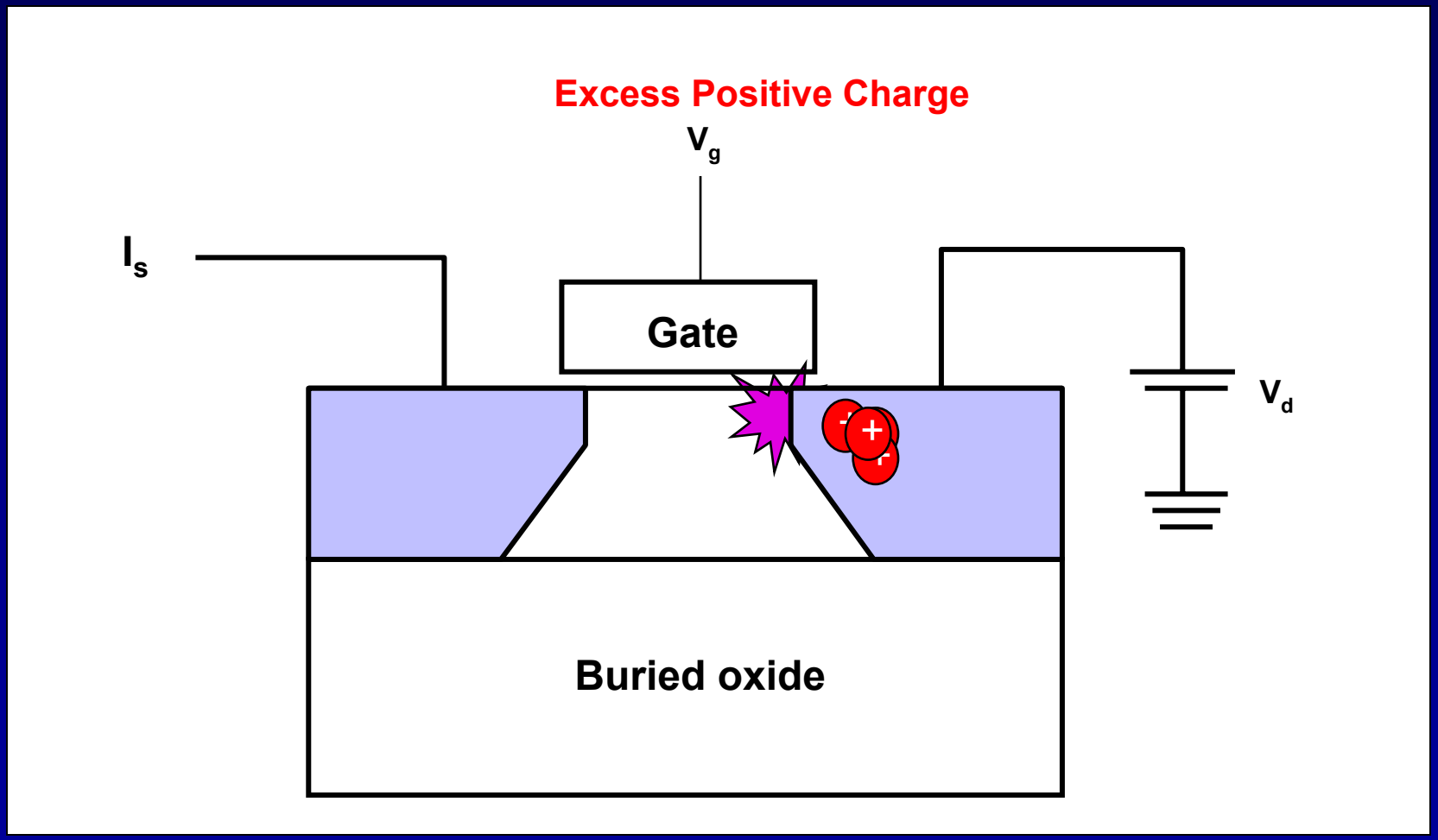


Logic "0"

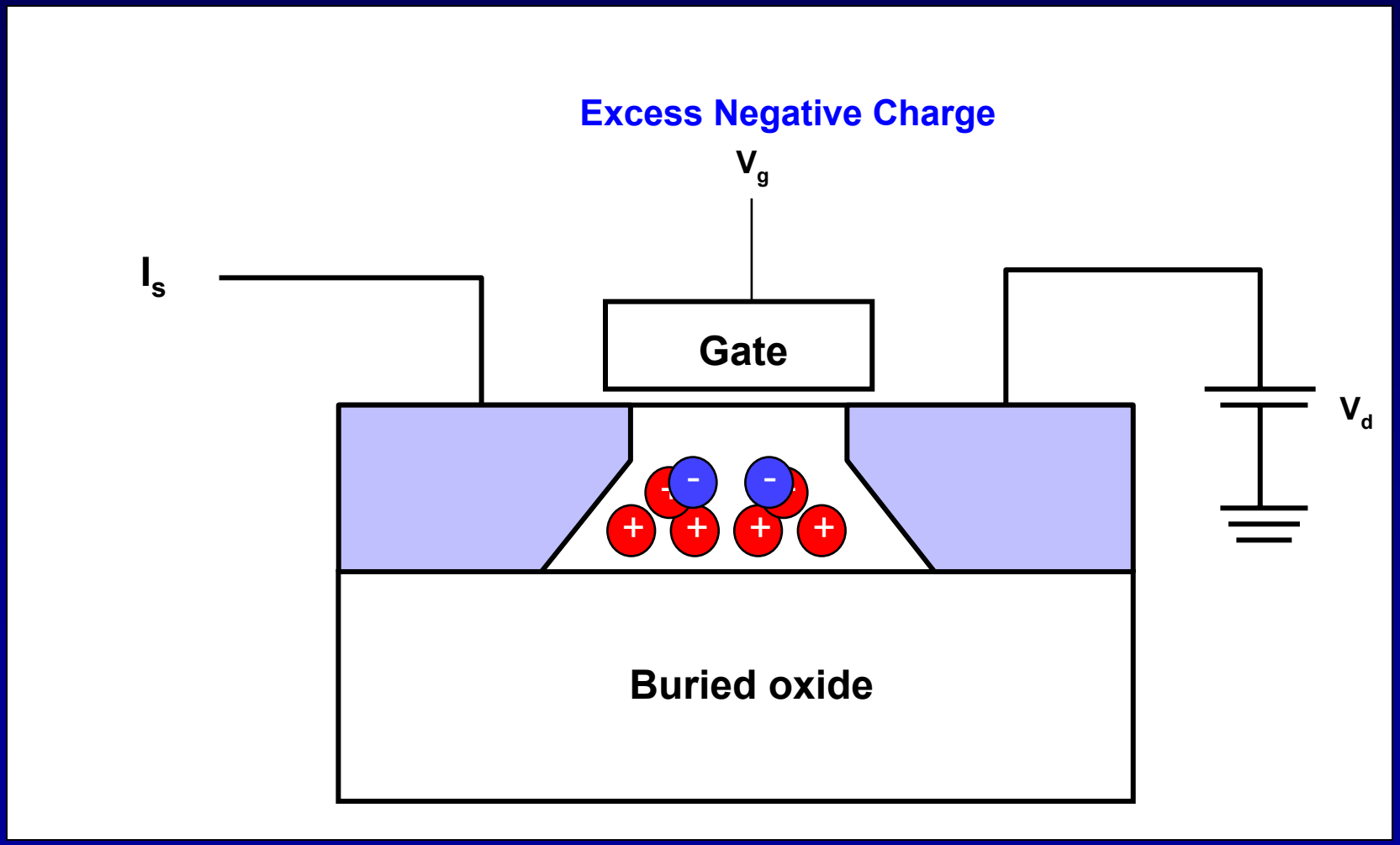




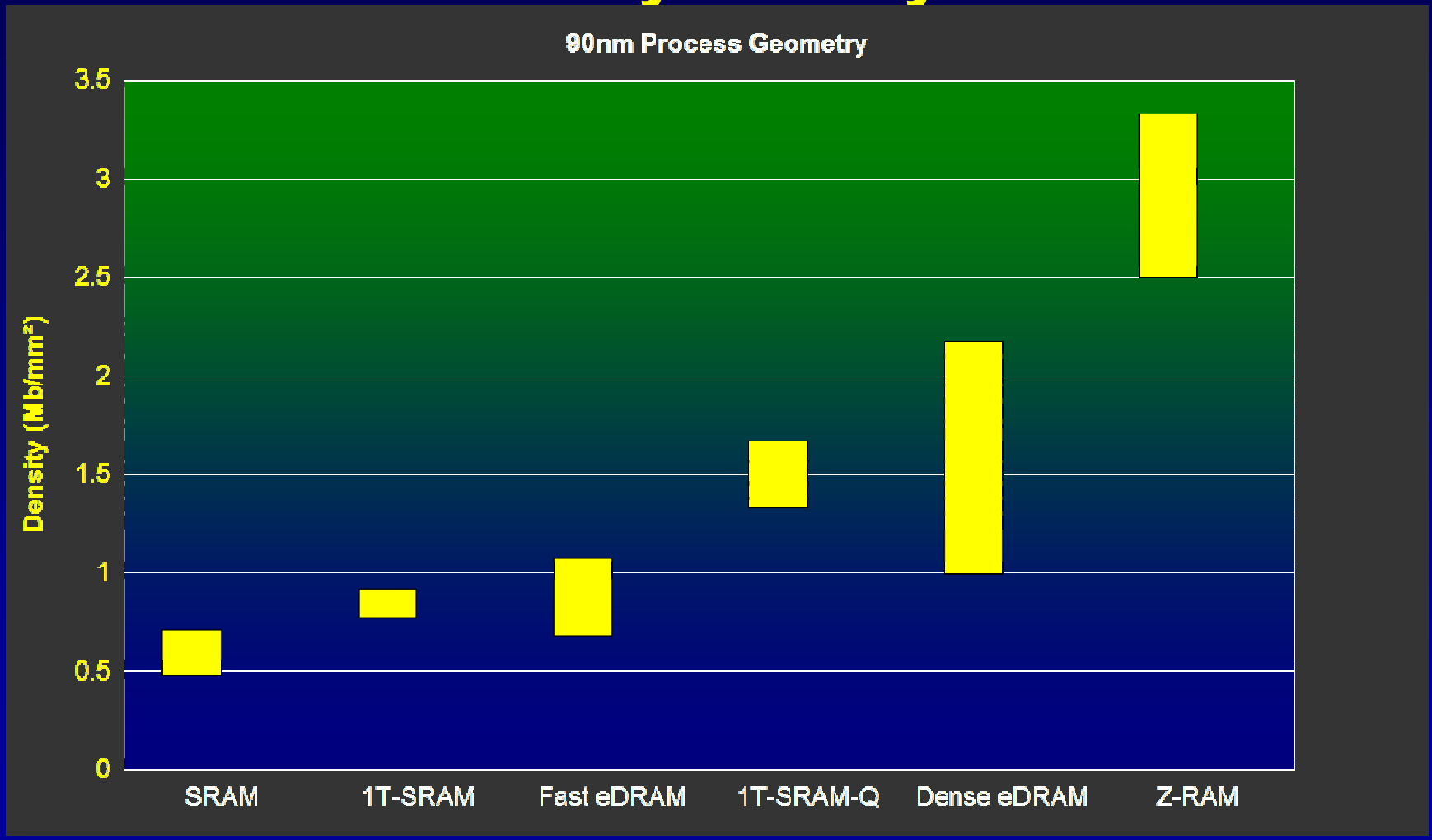
Writing “1” by impact ionization



Writing “0” by hole removal



Embedded memory density & economics



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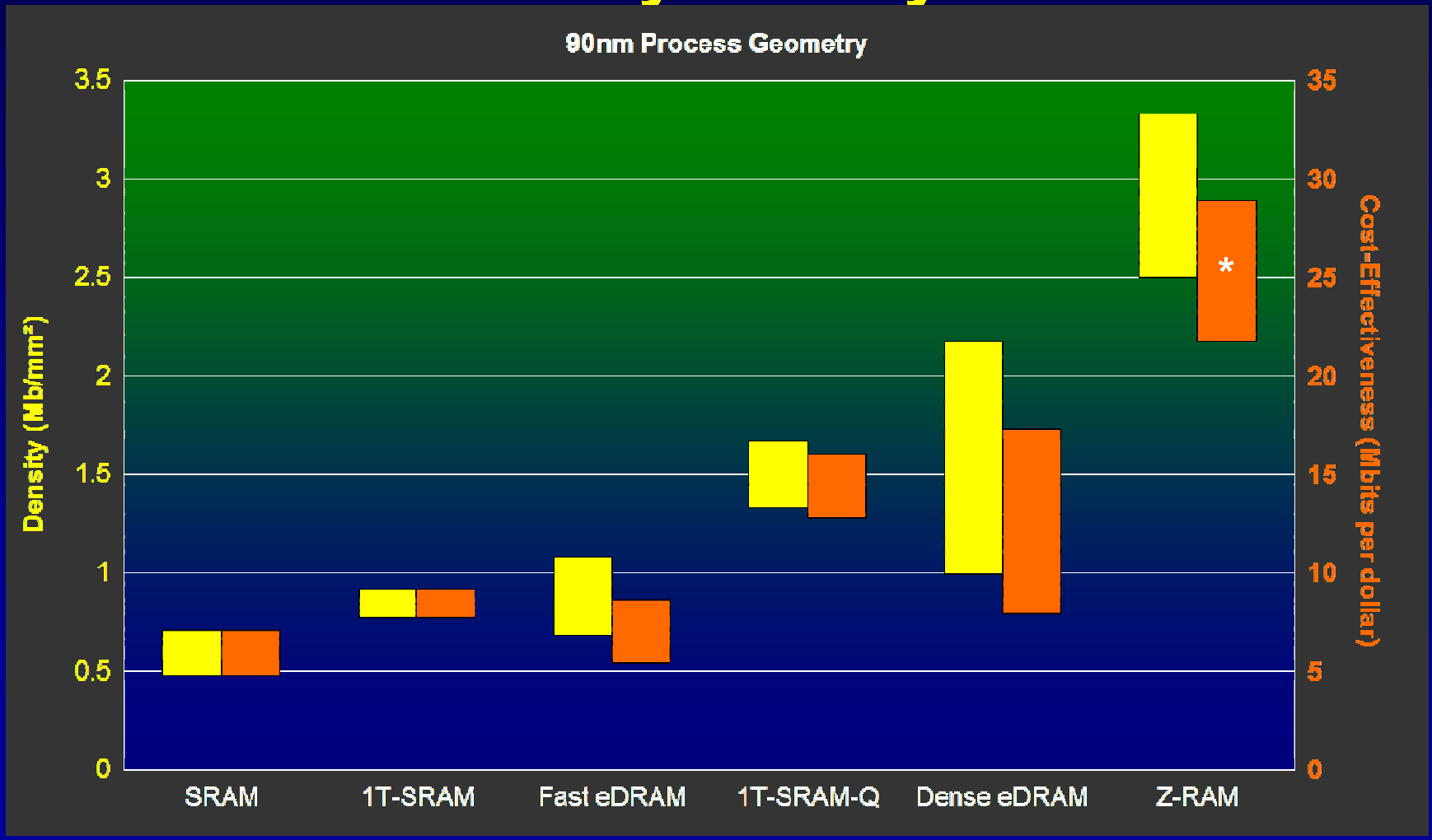
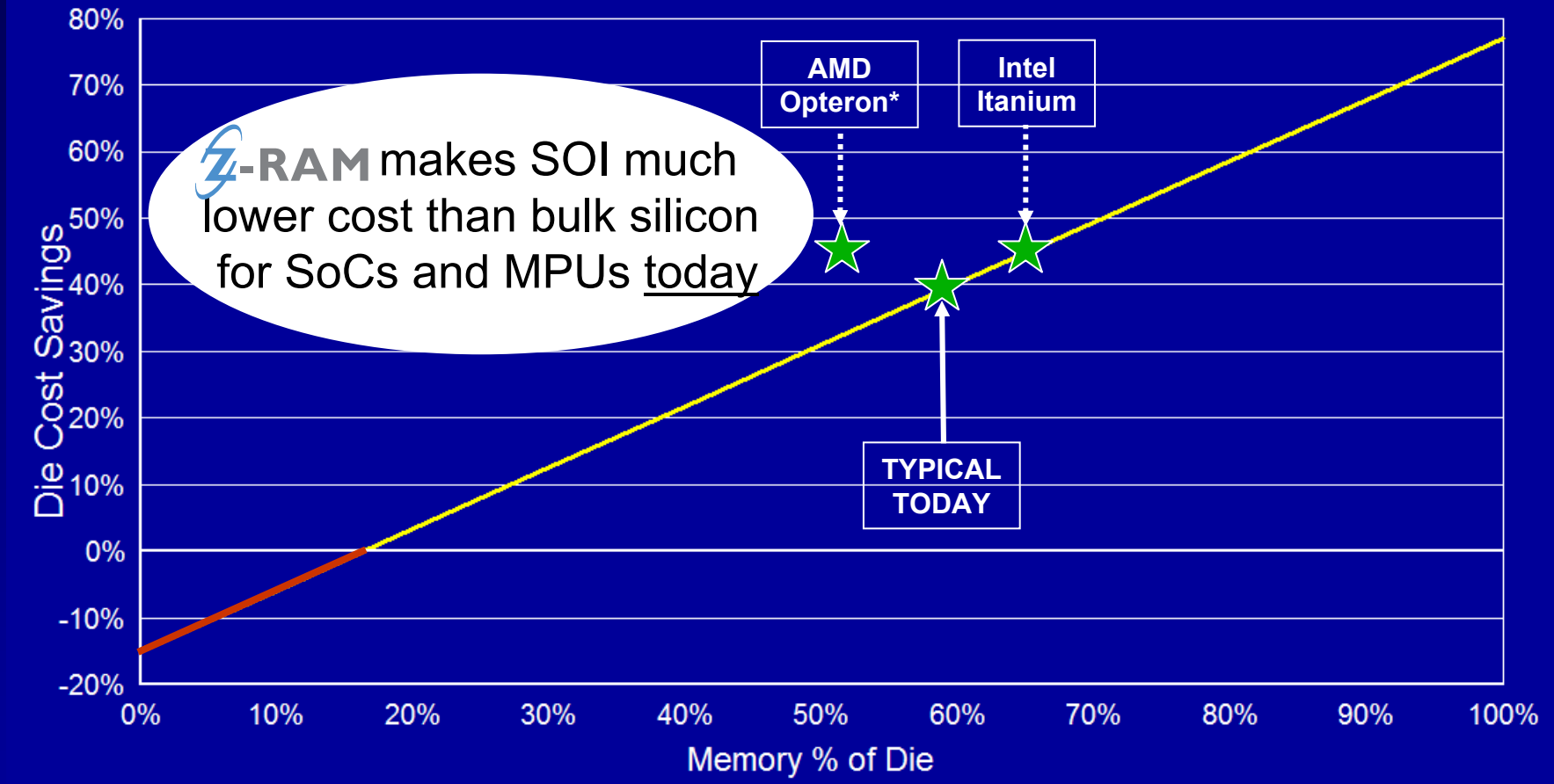
Embedded memory density & economics



* No extra steps, 15% cost increase for SOI vs. bulk silicon wafers

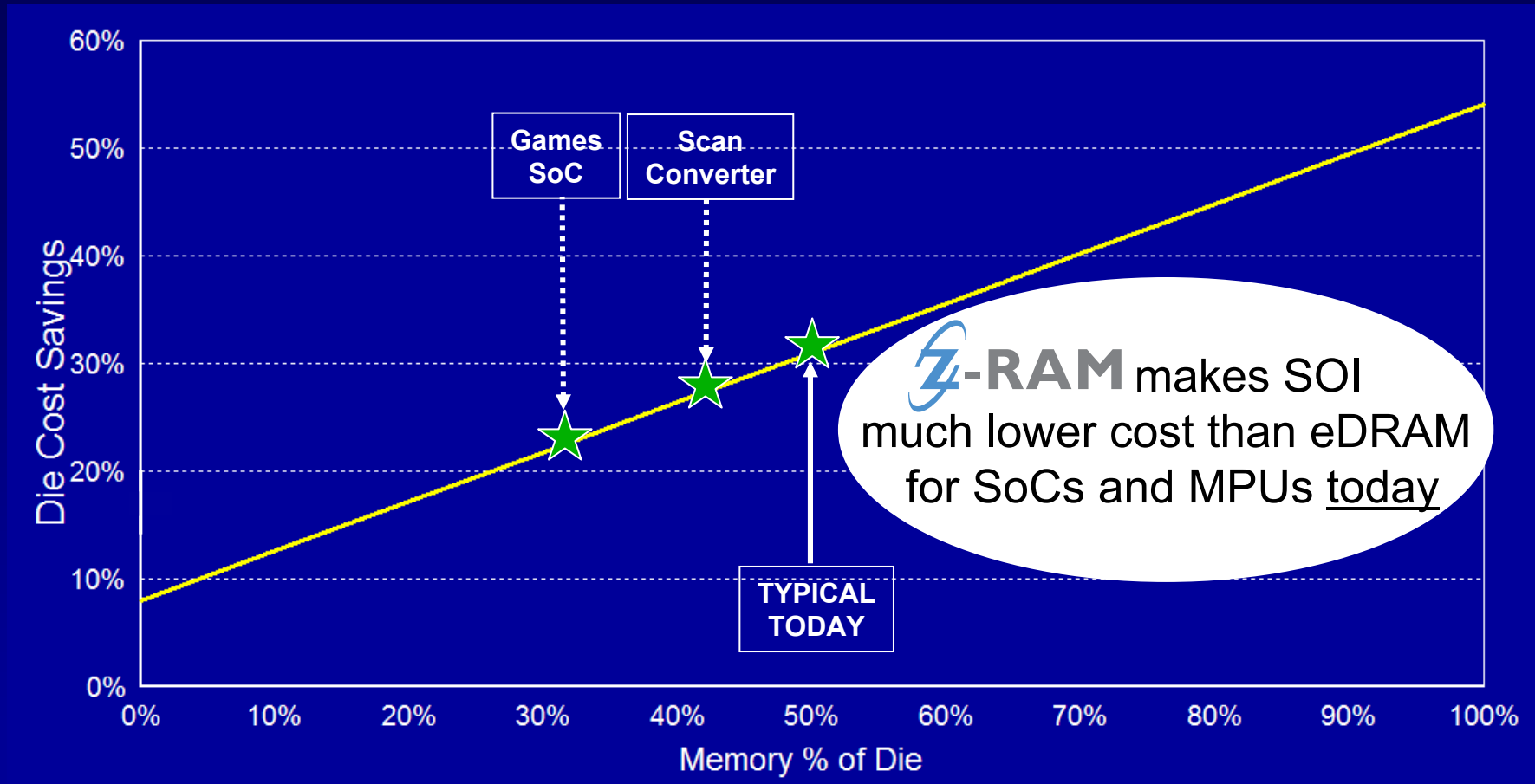
Savings using Z-RAM & SOI vs. SRAM & bulk



Figures assume 15% higher wafer cost for SOI

*AMD Opteron already uses SOI for performance, so savings are 15% higher

Savings using Z-RAM & SOI vs. eDRAM & bulk



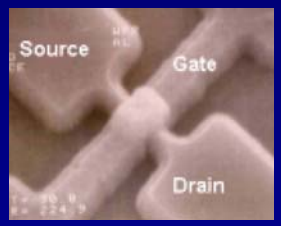
Figures assume 15% higher wafer cost for SOI and 25% higher for eDRAM

Z-RAM high-speed capability

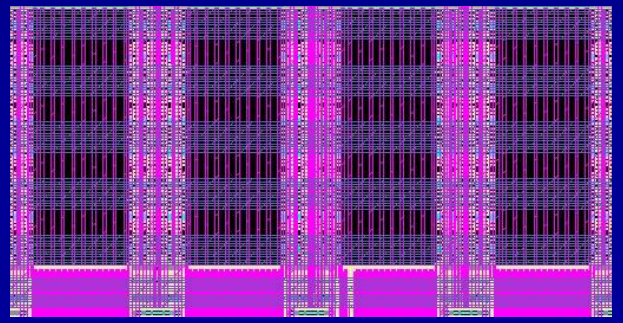
- Demonstrated < 3ns read & write on silicon
- Ultra-high density reduces wire lengths
  - Already faster than eDRAM
  - Promises very high speed as geometries shrink
  - Helps logic speed due to standard SOI logic process and reduced overall chip dimensions

Z-RAM technology status

- Silicon-proven at bit-cell level
  - Demonstrated at nine different foundries
  - Demonstrated down to L_{phys} = 40nm
  - Demonstrated on Partially Depleted (PD) & Fully Depleted (FD) SOI
  - Demonstrated on FinFET



- Megabit-size test chips fabricated in 90nm process
  - 65nm test chips currently in fab



ISi: IP-licensing business model

- Licensing Z-RAM for embedded use

- Flexible licensing models
  - Instance license
    - Licensee can use memory instance in chip designs
  - Technology license
    - Licensee can develop & modify memory designs themselves
  - Compiler license
    - Licensee can use memory compiler to generate instances

Summary

- Caches are dominating microprocessor die area & cost
- Existing embedded-memory solutions hitting scaling limits
- Ultra-dense, patented Z-RAM memory technology
  - Lowest cost, highest density semiconductor memory
    - 2x density of eDRAM, 5x density of SRAM
  - Uses standard SOI logic process
    - No new equipment, no new materials, no extra steps
- Makes SOI lower cost than bulk CMOS today
  - Will accelerate industry transition to SOI
- IP-provider business model
  - Flexible licensing options

Contact

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Ultra-Dense Embedded Memory Technology